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PERSISTENCE AND BIOACCUMUATION AS HAZARD IDENTIFICATION CRITERIA FOR METALS IN THE AQUATIC ENVIRONMENT
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The concept that metals are persistent is valid only in the sense that they remain as elements in the periodic table. Metals do not persist in terms of bioavailability and/or toxicity in the aquatic environment; metals dissolve as soluble salts in aquatic environments and are removed by adsorption, complexation, and sedimentation with water column residence half-lives of less than a month.

In the early 1970s the concepts of persistence, bioaccumulation, and toxicity were developed for the hazard identification of individual synthetic organic substances, pesticides and herbicides. The assumption underlying persistence is that quantities of an organic substance detected in the environment and that do not degrade will remain bioavailable and potentially toxic. Toxicity is no doubt a criterion for aquatic hazard identification of both organic and inorganic substances including metals. The question is how appropriate are persistence and bioaccumulation as criteria for assessing the environmental hazard associated with inorganic substances?

Experimental evidence shows that metals are readily and rapidly transported from water columns to sediments. Studies with metal radiotracers in field conditions (lakes and limnocorrals) have found that the half-life of dissolved metals in the water column is generally under 30 days. The process of deposition of metals into sediments also involves dramatic reductions in bioavailability and toxicity and over time these sediments are subject to diagensis and ultimate burial. These data make it difficult to sustain the concept that persistence of metals is a relevant criterion in terms of protecting the aquatic environment.

The bioconcentration factor (BCF) or bioaccumulation factor (BAF) measures the accumulation of a substance by an organism in relation to the exposure concentration. BCFs and BAFs are effective in predicting the potential for bioaccumulation and the environmental and toxicological properties of neutral organic chemicals of anthropogenic origin. Uptake of dissolved metals can be a complex process (generally much more so than hydrophobic/lipophilic organic substances) and both uptake and internal concentrations can often be physiologically controlled, particularly for nutritionally essential elements. This means that the relationship between internal accumulation and external exposure concentration (ie. BCF and BAF) varies. In fact, the BCF and BAF for all of the inorganic metals that have been tested vary inversely

with exposure concentration. Furthermore, internal accumulations of metals are not always related to effect. In some cases metals can accumulate without apparent effect while in others, effects can occur without significant accumulation. In other words, whether a metal accumulates (or not) is not necessarily related to the potential for expressing effects (toxicity). Again, nutritionally essential metals are a case in point but also, there is evidence that internalized metals can be physiologically sequestered and rendered effectively non-toxic.
Therefore, the bioaccumulation criterion (BCF and BAF) is an inappropriate measure for effectively assessing the potential for environmental hazard of metals (and other inorganic substances). BCF and BAF are measures of bioaccumulation; however, these measures are not related to the potential for the environmental hazard of inorganic substances. The overall concept of bioaccumulation is valid in terms of assessing environmental hazards, but the criterion through which the concept is applied needs to be modified.
The current persistence and bioaccumulation criteria, while appropriate for synthetic organic substances, are not suitable for metals. However, there is a growing use of hazard based criteria in regulatory approaches related to environmental protection. Therefore, in response to regulatory needs, ongoing research efforts are being directed towards developing alternative scientifically based and credible criteria for the hazard identification/assessment of metals.